

SERIAL COMMUNICATION DEVICE  
AND  
METHOD OF CARRYING OUT SERIAL COMMUNICATION

5 BACKGROUND OF THE INVENTION  
FIELD OF THE INVENTION

The invention relates to a serial communication device and a method of carrying out serial communication both used for confounding a memory in duplex, and more particularly to such a serial communication device and a method of  
10 carrying out serial communication both presenting the same reliability as reliability presented by a parallel bus.

DESCRIPTION OF THE RELATED ART

FIG. 1 is a block diagram of a conventional system for making  
15 communication in duplex confounding.

The system is comprised of a first parallel bus controller 10, a second parallel bus controller 12, a first buffer circuit 11a associated with the first parallel bus controller 10 and electrically connected between the first and second parallel bus controllers 10 and 12, a second buffer circuit 11b associated with the  
20 second parallel bus controller 12 and electrically connected between the first buffer circuit 11a and the second parallel bus controller 12, a 32-bit address bus 13, a 32-bit data bus 14, and a 5-bit parity 15.

The 32-bit address bus 13, the 32-bit data bus 14 and the 5-bit parity 15 are all electrically connected between the first and second parallel bus controllers  
25 10 and 12 through the first and second buffer circuits 11a and 11b.

Communication in duplex confounding between the first and second parallel bus controllers 10 and 12 is made through the 32-bit address bus 13 and the 32-bit data bus 14.

Errors in parallel buses, that is, in the 32-bit address bus 13 and the

32-bit data bus 14 are detected through the 5-bit parity 15.

The above-mentioned conventional system illustrated in FIG. 1 is accompanied with a problem that since the system has to include a lot of signal line for the parallel buses, the system unavoidably has a plurality of buffer circuits 11a and 11b, resulting in much defectiveness in fabrication of the system and high cost for fabricating the system.

It would be possible to accomplish reduction in both cost and defectiveness in fabrication of the system, if the parallel buses are replaced with serial buses. However, the use of serial bus causes another problem that bit errors occur during communication, and hence, it is impossible to ensure the same reliability as reliability obtained when parallel buses are used.

Japanese Patent No. 2971006 (Japanese Unexamined Patent Publication No. 8-265393) has suggested a method of carrying out serial communication in a serial communication controller including at least one first buffer for receiving data and at least one second buffer for transmitting data. In the method, the first buffer is used for receiving data and the second buffer is used for transmitting data when data is received and transmitted in full-duplex communication. The first and second buffers are used only for receiving data when data is received in half-duplex communication. The first and second buffers are used only for transmitting data when data is transmitted in half-duplex communication.

However, the above-mentioned problems remain unsolved even in the method suggested in the above-mentioned Publication.

## SUMMARY OF THE INVENTION

In view of the above-mentioned problems in the conventional system, it is an object of the present invention to provide a serial communication device and a method of carrying out serial communication both of which are capable of reducing the number of parts to thereby accomplish reduction in cost and

defectiveness in fabrication, and providing the same reliability as reliability obtained when parallel buses are used, even though serial buses are used in place of parallel buses.

In one aspect of the present invention, there is provided a serial  
5 communication device bridging between a parallel bus and a serial bus, including (a) a check bit producer which applies an error correcting code to parallel data transmitted through the parallel bus, and (b) a parallel-serial converter which converts the parallel data output from the check bit producer, into serial data.

The serial communication may further include a parallel bus interface  
10 circuit which multiplexes the parallel data transmitted through the parallel bus, in predetermined bits, and outputs the thus multiplexed parallel data to the check bit producer, in which case, the parallel-serial converter converts the parallel data into serial data every the predetermined bits, and the check bit producer applies the error correcting code to every the predetermined bits of the parallel data.

There is further provided a serial communication device bridging  
15 between a parallel bus and a serial bus, including (a) a serial-parallel converter which converts serial data transmitted through the serial bus, into parallel data, and (b) an error detector which checks an error correcting code applied to the serial data, and detects an error in the error correcting code.

It is preferable that the error detector has a function of correcting the  
20 error when the error is detected by the error detector.

It is preferable that the error detector corrects the error when the error is a 1-bit error, and abandons an access when the error is a 2-bit error.

There is still further provided a serial communication device bridging  
25 between a parallel bus and a serial bus, includes (a) a check bit producer which applies an error correcting code to parallel data transmitted through the parallel bus, (b) a parallel-serial converter which converts the parallel data output from the check bit producer, into serial data, (c) a serial-parallel converter which converts serial data transmitted through the serial bus, into parallel data, and (d)

an error detector which checks an error correcting code applied to the serial data, and detects an error in the error correcting code.

The serial communication device may further include a parallel bus interface circuit which (a) multiplexes the parallel data transmitted through the parallel bus, in predetermined bits, and outputs the thus multiplexed parallel data to the check bit producer, and (b) receives parallel data from the error detector, and outputs the received parallel data to the parallel bus, in which case, the parallel-serial converter converts the parallel data into serial data every the predetermined bits, and the check bit producer applies the error correcting code to every the predetermined bits of the parallel data.

In another aspect of the present invention, there is provided a method of carrying out serial communication between a parallel bus and a serial bus, including the steps of (a) applying an error correcting code to parallel data transmitted through the parallel bus, and (b) converting the parallel data into serial data.

The method may further include the step of (c) multiplexing the parallel data transmitted through the parallel bus, in predetermined bits, the step (c) being to be carried out prior to the step (a), in which case, the parallel data is converted into serial data every the predetermined bits in the step (b), and the error correcting code is applied to every the predetermined bits of the parallel data in the step (a).

There is further provided a method of carrying out serial communication between a parallel bus and a serial bus, including the steps of (a) converting serial data into parallel data, (b) checking an error correcting code applied to the serial data, and (c) detecting an error in the error correcting code.

The method may further include the step of (d) correcting the error detected in the step (c).

The method may further include the steps of (d) correcting the error when the error is a 1-bit error, and (e) abandoning an access when the error is a

2-bit error.

There is still further provided a method of carrying out serial communication between a parallel bus and a serial bus, including the steps of (a) applying an error correcting code to parallel data transmitted through the parallel bus, (b) converting the parallel data into serial data, (c) converting serial data transmitted through the serial bus, into parallel data, (d) checks an error correcting code applied to the serial data, and (e) detecting an error in the error correcting code.

The advantages obtained by the aforementioned present invention will be described hereinbelow.

In accordance with the present invention, the number of parts for constituting the communication system can be reduced to thereby accomplish reduction in cost and defectiveness in fabrication of the communication system, and the same reliability as reliability obtained when parallel buses are used can be provided, even though serial buses are used in place of parallel buses.

The above and other objects and advantageous features of the present invention will be made apparent from the following description made with reference to the accompanying drawings, in which like reference characters designate the same or similar parts throughout the drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a conventional system for making communication in duplex confounding.

FIG. 2 is a block diagram of the serial communication device in accordance with a preferred embodiment of the present invention.

FIG. 3 is a time chart showing an operation of the serial communication device illustrated in FIG. 1.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 2 is a block diagram of the serial communication device in accordance with a preferred embodiment of the present invention.

The serial communication device is comprised of a bus bridge circuit 8 electrically connected to a parallel bus 1 including a 32-bit address bus and a 32-bit data bus, a parallel-serial converting circuit 4 electrically connected between the bus bridge circuit 8 and a serial bus 5, and a serial-parallel converting circuit 6 electrically connected between the bus bridge circuit 8 and the serial bus 5.

The bus bridge circuit 8 is comprised of a parallel bus interface circuit 2 electrically connected to the parallel bus 1, a parallel-serial interface circuit 3 electrically connected between the parallel bus interface circuit 2 and the parallel-serial converting circuit 4, a serial-parallel interface circuit 7 electrically connected between the parallel bus interface circuit 2 and the serial-parallel converting circuit 6, a first 8-bit data-multiplexing bus 9a electrically connecting the parallel bus interface circuit 2 and the parallel-serial interface circuit 3 to each other, and a second 8-bit data-multiplexing bus 9b electrically connecting the parallel bus interface circuit 2 and the serial-parallel interface circuit 7 to each other.

The parallel and serial buses 1 and 5 may have any structure.

The parallel bus interface circuit 2 act as an interface to the parallel bus 1. When data is transmitted to the serial bus 5 from the parallel bus 1, the parallel bus interface circuit 2 multiplexes 32-bit address, data and command transmitted through the parallel bus 1, into 8-bit (1 byte) addresses, data and commands, and outputs the thus multiplexed addresses, data and commands to the parallel-serial interface circuit 3 through the first 8-bit data-multiplexing bus 9a. When data is transmitted to the parallel bus 1 from the serial bus 5, the parallel bus interface circuit 2 transmits data multiplexed into 1-byte data, to the parallel bus 1 as 32-bit address, data and command.

The parallel-serial interface circuit 3 acts as an interface for transmitting serial data, and produces a bit for checking an error correcting code

in serial communication (hereinafter, such a bit is referred to as "ECC check bit"). The parallel-serial interface circuit 3 receives address, data and command byte by byte from the parallel bus interface circuit 2, produces a ECC check bit on receipt of 1-byte of address, data and command, applies the thus produced ECC check bit to each 1-byte of address, data and command, and outputs each 1-byte of address, data and command with the associated ECC check bit, to the parallel-serial converting circuit 4.

The parallel-serial converting circuit 4 receives the parallel data byte by byte from the parallel-serial interface circuit 3, converts the received parallel data to serial data, and outputs the thus converted serial data to the serial bus 5.

The serial-parallel converting circuit 6 receives serial data through the serial bus 5, converts the received serial data to parallel data byte by byte, and outputs the thus converted parallel data to the serial-parallel interface circuit 7.

The serial-parallel interface circuit 7 detects a ECC check bit, corrects errors in error correcting codes, and acts as an interface for transmitting parallel data. Specifically, the serial-parallel interface circuit 7 checks ECC check bits in address, data and command to thereby detect errors in error correcting codes, and corrects the detected errors. Then, the serial-parallel interface circuit 7 converts 1-byte data transmitted from the serial-parallel converting circuit 6, into 32-bit address, data and command, and multiplexes the 32-bit address, data and command into 8-bit (1 byte) addresses, data and commands, and outputs the thus multiplexed addresses, data and commands to the parallel bus interface circuit 2 through the second 8-bit data-multiplexing bus 9b.

The serial-parallel interface circuit 7 checks the ECC check bits in address, data and command to thereby detect errors in the error correcting codes. If the serial-parallel interface circuit 7 detects a 1-bit error in the error correcting codes, the serial-parallel interface circuit 7 corrects the detected 1-bit error, whereas if the serial-parallel interface circuit 7 detects a 2-bit error in the error correcting code, the serial-parallel interface circuit 7 abandons an access

associated the detected error.

FIG. 3 is a time chart showing a relation among addresses, data, commands and ECC check bits.

Hereinbelow is explained an operation of the serial communication  
5 device in accordance with the embodiment.

When data is transmitted to the serial bus 5 from the parallel bus 1, the parallel bus interface circuit 2 multiplexes 32-bit address, data and command transmitted through the parallel bus 1, into 8-bit (1 byte) addresses, data and commands, and outputs the thus multiplexed addresses, data and commands to  
10 the parallel-serial interface circuit 3 through the first 8-bit data-multiplexing bus 9a.

The parallel-serial interface circuit 3 receives address, data and command byte by byte from the parallel bus interface circuit 2, produces a ECC check bit on receipt of 1-byte of address, data and command, applies the thus  
15 produced ECC check bit to each 1-byte of address, data and command, and outputs each 1-byte of address, data and command with the associated ECC check bit, to the parallel-serial converting circuit 4.

The parallel-serial converting circuit 4 receives the parallel data byte by byte from the parallel-serial interface circuit 3, converts the received parallel  
20 data to serial data, and outputs the thus converted serial data to the serial bus 5.

When data is transmitted to the parallel bus 1 from the serial bus 5, address, data and command are transmitted to the serial-parallel converting circuit 6 through the serial bus 5, and are converted into parallel data in 1-byte in the serial-parallel converting circuit 6. The thus converted 1-byte parallel data  
25 are transmitted to the serial-parallel interface circuit 7.

The serial-parallel interface circuit 7 converts the 1-byte serial data transmitted from the serial-parallel converting circuit 6, into 32-bit address, data and command, and multiplexes the 32-bit address, data and command into 8-bit (1 byte) addresses, data and commands, and outputs the thus multiplexed



addresses, data and commands to the parallel bus interface circuit 2 through the second 8-bit data-multiplexing bus 9b.

In addition, the serial-parallel interface circuit 7 checks the ECC check bits in address, data and command to thereby detect errors in the error correcting codes. If the serial-parallel interface circuit 7 detects a 1-bit error in the error correcting codes, the serial-parallel interface circuit 7 corrects the detected 1-bit error. If the serial-parallel interface circuit 7 detects a 2-bit error in the error correcting code, the serial-parallel interface circuit 7 abandons an access associated the detected error.

The 32-bit address, data and command are transmitted to the parallel bus interface circuit 2 from the serial-parallel interface circuit 7, and then, transferred to the parallel bus 1 through the parallel bus interface circuit 2.

The parallel-serial interface circuit 3 produces the ECC check bits for address, data and command, and applies the ECC check bits to each 1-byte of address, data and command at timings illustrated in FIG. 3 in accordance with clock pulses.

Similarly, the serial-parallel interface circuit 7 checks the ECC check bits in address, data and command at timings illustrated in FIG. 3 in accordance with clock pulses.

While the present invention has been described in connection with certain preferred embodiments, it is to be understood that the subject matter encompassed by way of the present invention is not to be limited to those specific embodiments. On the contrary, it is intended for the subject matter of the invention to include all alternatives, modifications and equivalents as can be included within the spirit and scope of the following claims.

The entire disclosure of Japanese Patent Application No. 2000-310113 filed on October 11, 2000 including specification, claims, drawings and summary is incorporated herein by reference in its entirety.